COPP/SS/4/1963

REPORT
ON
PRIMARY SCHOOL BUILDINGS
IN
DELHI

GOVERNMENT OF INDIA
COMMITTEE ON PLAN PROJECTS
NEW DELHI
July, 1963.

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I - INTRODUCTION

The Problem:

With the phenomenal rise in population in Delhi the demand for educational facilities has also increased enormously at all levels. At the primary school level, the problem has become much more acute in view of the intensified efforts to enforce compulsory education for the age group 6 to 11 years. Whereas the number of students in primary/junior basic classes in Delhi in 1951-52 was 1,30,061, it rose to 2,76,088 in 1959-60 and to 2,85,386 in 1960-61. It is anticipated that by the end of the Third Plan about 4,08,000 of children (99.5%) in the age group 6-11 will be at school.

2. The total number of primary (including junior basic) schools in Delhi was 538 in 1951-52. It rose to 645 in 1959-60, 718 in 1960-61 and 793 in 1961-62. Most of these schools are, however, under the control of the Municipal Corporation of Delhi as would be evident from the following table:-

Year	Enrolment	Number of schools run by the Corporation
1958-59	1,49,260	542
1959-60	1,77,522	576
1960-61	2,02,421	644
1961-62	2,45,398	706
1962-63	2,78,050	763

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In addition, there were 230 middle schools in the Corporation area in 1962-63 with primary classes attached to them.

3. As indicated above, the total number of primary schools at the end of the Second Plan was 644. It is estimated that another 516 primary schools would be added by the end of the Third Plan. The Corporation established 216 primary schools during the first two years of the Third Plan and proposes to add 100 such schools every year during the remaining three years of the Plan. The provision for school buildings during the Third Plan is as follows:-

Year	Provision	Actual Expenditure
1961-62	Rs 29 lakhs	Rs 8.28 lakhs
1962-63	Rs 60 lakhs	Rs 48.99 lakhs
1963-64	Rs 40.45 lakhs	-
1964-65	Rs 45.72 lakhs	-
1965-66	Rs 45 lakhs	-

4. It has not been possible for the Corporation authorities to construct the required number of new buildings for such schools. There is scarcity of land in certain congested urban areas where the demand for schooling facilities is the greatest. Improvised schools in the form of tented accommodation or temporary structures have been raised to meet the growing demand for schooling facilities. The Corporation authorities have had to incur an infructuous expenditure of Rs 2 lakhs (approx.) per year on rent, repairs etc. of the school tents whose number during the period 1959-62 was about 1000.

Requirements:

5. During the current year, the Corporation needs about 1000 class rooms, each class room to accommodate 35-40 students. Out of these, about half would be by way of additions to the existing primary schools and the remaining to be new schools; at least 100 of which will be in rural area. The schools to be constructed in the urban area will be in the new colonies on the outskirts of the city. In view of the ever-increasing need for school buildings, the Corporation authorities approached the Ministry of Education for an ad hoc grant for constructing more primary school buildings in the Capital. The Ministry, however, suggested that a suitable and economical design for a primary school building be evolved before undertaking further construction and requested the Committee on Plan Projects for assistance. Accordingly, a broad-based and composite Panel was set up with the following composition:-

1.	Shri B.N. Jha. Vice - Chancellor, Jodhpur University, Jodhpur	Chairman
2.	Shri K.L. Joshi, Chief, Education Division, Planning Commission, New Delhi.	Member
3.	Shri R.K. Bountra, Education Officer, Delhi Municipal Corporation, Delhi.	Member
4.	Shri J.P.J. Billimoria, Senior Architect, C.P.W.D., New Delhi.	Member

5. Miss S. Rajan, Asstt. Educational Adviser, Ministry of Education, New Delhi	Member
6.. Shri M.M. Patel, General Manager, Hindustan Housing Factory, New Delhi	Member
7. Shri B.L. Chadha, Consulting Architect, New Delhi	Member
8. Shri M.D. Paul Manickam, Executive Engineer, Building Projects Team, COPP New Delhi.	Member
9. Shri Jagdish Singh, Committee on Plan Projects, New Delhi.	Member-Secretary

6. The Panel undertook a detailed study of the primary school buildings constructed by the Corporation authorities, visited a number of them in the rural and urban areas of Delhi and had detailed discussions with the Corporation authorities and in the meetings of the Panel.

7. We would like to place on record our appreciation for the willing cooperation extended by Central Building Research Institute, Roorkee, at every stage of our work and for deputing their officers and staff to assist us. Particular mention may be made of the very valuable contribution made by Shri M.H.Pandya, Architect, Shri H.V. Mirchandani, Asstt. Director, C.B.R.I. Roorkee and their staff. Our thanks are due to Shri D.N.Khurana, Asstt. Engineer, Municipal Corporation of Delhi who spared no pains in personally supervising the construction of the model class room and in assisting the Members of the Panel in every way. We are also grateful to Shri T.S.Vedagiri, Member-Secretary, Building Projects Team for the very valuable guidance given by him at every stage of the work of the Panel.

II - SPACE REQUIREMENTS

Existing Pattern of Accommodation

A survey of the existing primary schools, constructed by the Municipal Corporation of Delhi, revealed that the dimensions for various types of accommodation in primary schools are as follows:-

1. Class room: 19'-3"x20', 18'x22', 14'x24', 18½'x16¼', 12'x22'.
2. Headmaster/Headmistress's room: 14'x14', 13'-8¾"x10'-3½" and 12'x12'-1½"
3. Store room: 14'x14', 19'-8¾"x9'-3" and 14'x7½"
4. Water room: 14'x8' and 10'x7½"

2. During visits to various schools, it was found that the class-room area per student varied from school to school ranging from 7 sq.ft. to 10 sq.ft. No uniform dimensions appeared to have been laid down for a class room. Similarly, there were variations in the area of the headmaster/headmistress's room and other ancillary accommodation.

Suggested Dimensions:

3. In previous studies* on the subject, an area of .92 sq.m. (10 sq.ft.) per pupil has been recommended for primary schools and 1.1 sq.m. (12 sq.ft.) per pupil for middle and high schools. The COPP Panel on Delhi School Buildings** recommended 1.1 sq.m. (12 sq.ft.) per student for a higher secondary student if dual desks are used in class rooms. In the case of primary schools, this Panel is of the view that an area of .65-.74 sq.m. (7-8 sq.ft.) per student should suffice if the students are to be seated on the floor on tat patties (coir matting). An area of 29.69 sq.m. (320 sq.ft.) would, therefore, be adequate for a class of 40 students; the dimensions of the class room being 6.09mx4.87m (20'x16'). Keeping in view the future possibilities of replacing tat patties by desks,

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*Planning School for India, Ministry of Education 1959.

**Report on Delhi School Buildings, Committee on Plan Projects, Government of India, 1960.

benches etc. an area of about .83 sq.m. (9 sq.ft.) per student may be provided i.e., a total area of 32.73 sq.m. (352 sq.ft.) for a class room, keeping the dimensions as 6.70x4.87 sq.m. (22'x16').

Fittings in a Class Room:

4. A class room should have the following minimum fittings and fixtures:

i) A built-in cupboard or ledges/projections for storing the material and for displaying the finished products, paintings, etc. of children.

ii) Wooden picture railings all around the walls of the class room or at least on one side for display of pictures, paintings, charts, etc.

iii) A built-in cement blackboard (which is preferable to the portable wooden blackboard).

iv) Hooks / clamps for at least two ceiling fans.

Flooring:

5. Ordinary dry brick flooring has been tried in primary school class rooms but experience shows that such class rooms are usually found to be dirty and dusty, nor are they durable. It is therefore strongly recommended that class rooms should have cement concrete flooring.

Doors & Windows:

6. The provision of doors and windows in a class room was studied in detail and the Panel came to the conclusion that a class room need not have more than one entrance door. There appears to be no justification for two doors. Besides saving on cost, this gives functionally a more compact area. Three windows, one on the door wall and two on the opposite wall, may be provided in each class room for proper ventilation and lighting. A chajja (sun shade) with 1½'-2' projection may be provided on the windows, keeping in view the orientation of the building.

Verandahs:

7. Verandahs are usually provided for circulation and in certain regions for protection against inclement weather. The primary school children do not have to move from one room to another for their studies. They stay mostly in the same room throughout the day.

The Panel is, therefore, of the view that a covered verandah is not necessary for a primary school since it would unnecessarily add to the cost without being of much use. With a view to keeping the surroundings of the class room clean and to prevent dust and dirt creeping into the class room with the foot-steps of children, a three-feet wide dry brick flooring may be provided along the class rooms as shown in the layout. It may, however, be necessary to have a small lobby (2.44 m. or 8 ft. wide) in front of the office for various purposes like seating the visitors, attendents etc.

Floor Height:

8. The floor height is a significant factor in the cost of a building. Experiments have shown that a floor height of more than 2.74 m. (9 ft.) does not add significantly to physical comfort. The Panel, however, recommends that a floor height of 3.05 m. (10 ft.) would be adequate for a class room.

Plinth Height:

9. In the buildings visited, the height of the plinth veried from 0.15 m. - 0.48 m. (6" to 1'-6"). For buildings of this type, a plinth height of 0.30 m. (1') above the crust of the nearest road should be adequate.

Ancillary Accommodation:

10. Ancillary accommodation in the school usually consists of:-

i) Headmaster's room

ii) Store room

iii) Water room

iv) Sanitary facilities

The Panel is of the view that the dimensions given below would be adequate for ancillery accommodation:

i) Headmaster's room	3.96 m. x 3.23 m. = 12.70 sq.m. (13'x10'-7½" = 138sq.ft. approx.)
ii) Store-cum-water room (to be divided into two sections viz. Store room 3.23 m. x 2.93 m. = 9.45 sq.m. (10'-7½"x9'-7½=102sq.ft. approx.) & water room 3.23 m. x 1.83 m. =6.03 sq.m. (10'-7½" x 6' = 64 sq.ft. approx.)	-do-

11. It is also suggested that the office of the headmaster/headmistress should have at least two built-in cupboards. The store room may also be provided with an adequate number of built-in shelves for storing games equipment and other miscellaneous things.

Sanitary facilities:

12. Primary schools usually lack sanitary facilities with the result that children actually use the surroundings of the school making the school premises insanitary. The Indian Standards Institution, Delhi have given detailed specifications for sanitary facilities in respect of schools of various categories (vide Appendix - I). Local bodies have also laid down bye-laws for sanitary facilities relating to schools and other places constructed in their jurisdiction. The school authorities may follow the I.S.I. standards or those prescribed by local authorities. The Panel would, however, urge strongly that while planning the building, due attention should be paid to the provision of adequate sanitary facilities. Where proper drainage system is not available, the sanitary facilities may be provided at some distance from the main building. Several types of latrines such as the bore-hole type latrine with septic tank and dispersion trench etc. have been tried. A deep pit with broken bricks has been tried with success for urinals. Any of these can be adopted depending upon local conditions.

Total Accommodation for a Primary School:

13. The minimum requirements for a one-section primary school is as follows:-

i. Class rooms 5 (one for each class)

ii. Ancillary accommodation

a) Headmaster/Headmistress's Room - 1

b) Store-cum-water room - 1

c) Sanitary facilities (according to I.S.I. standards or local bye-laws).

14. Where there is more than one section, additional class rooms may be provided but it will not make any material difference in the ancillary accommodation except for sanitary facilities if the number of students is very large.

Assembly Hall:

15. An assembly hall is not considered necessary for primary schools. The school assemblies are held in the open in front of the class rooms or in the school compound if there is one. In rural areas the school may sometimes be expected to serve as a Community Centre after school hours. For small villages a class room may be quite adequate for community gatherings. In bigger villages, where there is need for an assembly hall to accommodate larger groups and a Community Centre or a Panchayat Ghar is not available, a sliding and folding partition may be provided between two class rooms so as to convert them into a hall when required. Such a hall could easily accommodate a large community gathering, if and when a function is to be held indoors. Larger gatherings can be held in open air as is the practice in rural areas.

Economy in space

16. The above recommendations would thus lead to economy in the space requirements for a five-class room school as indicated in the table on the next page:-

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Category	Original Dimensions Permanent/ Semi-permanent	 Sloping (Pent) roofed structure (Tubular)	Suggested Dimensions	Saving (Col.2-4)	 (Col.3-4)
1. Class Rooms (5)	5.48 m.x6.70 m.x5= 183.91 sq.m. (18'x22'x5=1980)	5.86 m.x6.02x5=176.70 sq.m. (19'-3"x19'-8¾"x5=1900	4.87mx6.70mx5= 163.65 sq.m. (16'x22'x5=1760)	20.46 (220)	13.02 (140)
2. Headmaster/ Headmistress's office.	3.65mx3.69m=13.45sq.m. (12'x12'-1½"=145)	4.19mx3.137m=13.11 sq.m. (13'.8¾"x10'.3½"=141	3.96mx3.23m=12.83 sq.m. (13'x10'.7½"=138)	.65 (7)	.28 (3)
3. Store room	4.267mx2.134m=9.74sq.m. (14'x7½'=105)	6.07mx2.81m=16.98 sq.m. (19'-8¾"x9'-3"=183)	3.23mx2.93m=9.46 sq.m. (10'-7½"x9'-7½" =102)	.278 (3)	7.50 (81)
4. Water room	3.05mx2.13m=6.96sq.m. (10'x7½'=75)	3.05mx1.82m=5.57sq.m. (10'x6'=60)	3.23mx1.83m= 5.938sq.m. (10'-7½"x6'=64)	1.01 (11)	(-).37 ((-)4)
Total	214.36 sq.m. (2305)	212.41 sq.m. (2284)	191.95 sq.m. (2064)	22.41 q.m. (241) (10.5%)	20.46sq.m. (220) (9.6%)

III - DESIGN AND SPECIFICATIONS

Present types of construction

From structural considerations, the primary school buildings so far constructed by the Municipal Corporation fall under the following categories:

i) Permanent type of buildings with superstructure of brick work and RCC roofing. In certain cases the roofing over verandah is of asbestos sheets.

ii) Sloping (Pent) roofed structures with tubular columns and trusses roofed with asbestos sheets: panel walls of brick in mud upto ceiling.

iii) Sloping (Pent) roofed structures with tubular columns, angle iron trusses and purlins, roofed with asbestos sheets. Panel walls 1.52 m. (5') high of brick in mud and brick on edge flooring. These structures do not have doors and windows.

Detailed specifications of these structures and plinth area rate of construction are given in Appendix II.

2. The sloping-roofed structures have been the subject of public criticism. Such buildings have not been found to be very convenient for the primary school children. Besides, they do not harmonise with the surroundings of the new colonies that have sprung up all over Delhi and New Delhi and are, therefore, not acceptable to the residents of such localities since they look like sheds and are regarded as an apology for a school building. Other types of construction have been found to be costly.

Design:

3. Members of the Panel visited a few selected schools constructed by the Corporation to study the merits and demerits of each structure. Various alternatives were studied and discussed in the meetings of the Panel keeping in view the urgent needs of the Corporation. The possibilities of securing components for these structures were explored by the Corporation authorities. Asbestos sheets formed an important part of the economical structure adopted by the Corporation. The scarcity of such sheets during the present emergency further complicated the/problem. It was, therefore, decided by the Panel that an alternative economical design may be evolved which would obviate the need for asbestos sheet roofing.

4. It was brought to the notice of the Panel that the Central Building Research Institute, Roorkee had evolved an economical structure of a school building with a flat roof of doubly curved pre-cast tiles on reinforced joists, having brick-in-mud walls, a model of which had been built by them in one of the villages in the neighbourhood of Roorkee. A few members of the Panel, therefore, visited the village and studied this building.

5. The cost of R.C.C. roof usually amounts to 25-30% of the total building cost. In terms of money, its cost ranges between Rs 2.50 to Rs 4.00 per sq.ft. (depending on the span and loads to be carried) out of which 75-80% forms the cost of the slab and 20-25% forms the cost of framework. The roof structure designed by C.B.R.I. consists of small doubly curved tiles 0.66 cm. x 0.66 m. x 1.90 m - 2'.2"x2'.2"x¾" thick of plain cement concrete, 1:2:4 with an aggregate of .952 cm. (3/8") size. These tiles can be cast with the help of a timber frame work of the required size with a piece of hessian cloth tacked on to it. These tiles are placed on partially pre-cast RCC beams (supported during construction) with a compression flange of in situ concrete. Haunches of tiles and compression flange of R.C.C. joists are filled with cement concrete of 1:2:4. An average of 10.16 cm. (4") thick lime concrete is provided over the surface to provide a protective layer and insulation. Since the roof gains its full strength only after the insitu concrete is fully set and since individual tiles do not have very high impact strength, care is taken to ensure that the roof is not subjected to heavy or concentrated loads far in excess of design loads, during the construction or subsequently.

6. The cost of this building was reported to be Rs 4.50 per sq.ft. at Saliar Village near Roorkee. It was suggested by the representative of the Corporation that a model class room according to these specifications for the roof may be constructed in Delhi for approval by the Corporation authorities. The C.B.R.I. authorities very kindly agreed to assist the Corporation and sent their technical staff and masons for this purpose. The model class room was constructed in the compound of one of the Corporation schools in Karol Bagh, New Delhi. The doubly curved tiles were pre-cast at site by local masons under the guidance of the technical staff of the C.B.R.I.

Specifications:

7. The roofing conformed to the following specifications:-

(a) 1.90 m. (3/4") thick concrete (1:2:4 W/c 0.55 nominal) tiles of doubly curved shape, cast on specially made forms or generated on tiles of similar shape, cast and curved as per recommendations given in the Building Digest No. 5 issued by C.B.R.I., Roorkee.

(b) Secondary R.C.C. Tee Beam partly precast, partly cast in situ supported during construction, size to suit loading requirement as per conventional design.

(c) Main R.C.C. rectangular beam either of single or double reinforced type-size to suit loading requirement as per conventional design.

(d) Thermal protection as per conventional specifications 4" thick (average) mud-phuska.*

8. The cost of this class room works out to Rs 8.21 per sq.ft. (Rs 6.6∠scheduled rates+ 25% allowed on account of increase in prices as per detailed estimates given in Appendix III). This compares favourably with the permanent and semi-permanent buildings previously constructed by the Corporation at a cost of Rs 12.00 and 10.00 per sq.ft. respectively. The cost of even the tubular structure works out to Rs 8.75 per sq.ft. while∠estimated cost of a class room of the size suggested by us, according to above specifications, which conform to a permanent structure, would be Rs 3,375/- resulting in a saving amounting to about Rs 1557/- , 735/- and 225/- per class room as compared with the permanent, semi-permanent and tubular structures respectively.

∠at

∠ that of the improvised structures at Rs 5.62 per sq.ft. The

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* C.B.R.I., however, use & recommend lime concrete.

Recommendations for Future Construction:

9. The Panel discussed the various alternatives of an economical structure for a primary school. The present structures, constructed by the Corporation with tubular/angle iron, trusses and A.C.C. sheet roofing, have the advantage of speedy construction if the components are readily available. These class rooms have not, however, been found to be comfortable during extremes of weather. They are particularly warm in summer. Besides, they are not economical in view of the high cost of A.C.C. sheets and tubular/angle iron trusses.

10. If planning of the additional requirements of class rooms/schools is undertaken sufficiently in advance and proper programming is done, the need for rushing through constructions with such components may not arise. Moreover, the supplies of A.C.C. sheet roofing for civilian needs is becoming more and more difficult. We were informed that the Corporation authorities had already secured supplies of some of the components for these structures and, in view of their urgent needs, they may have to undertake the construction of some of their additional class rooms with these components. We would, however, suggest the following modifications in this type of building:

i) The gable wall trusses may be eliminated.

ii) The size of angle iron for purlins may be increased.

iii) The walls may be raised to full height.

iv) Each class-room may be provided with a built-in cupboard or shelf.

v) Proper ventilation may be provided.

11. The Panel, however, recommends strongly the adoption of the economical design with doubly curved tile roofing. This structure is as good as a permanent structure for a single-storey building and is very economical at a cost of Rs 8.21 per sq. ft. of plinth area. In fact the mode class room constructed in accordance with these specifications has been appreciated and approved by the authorities of the Municipal Corporation of Delhi.

12. The process of manufacturing doubly curved tiles is quite simple and any local mason could be initiated into the process in a day. If circumstances so demand, the tiles can be manufactured at one site and transported easily to different sites; the breakage has been estimated as no more than 5% by rough handling etc. Detailed specifications and instructions about the manufacture of doubly curved tiles are given in Appendix - IV. A detailed lay-out of a 5 class room primary school, with the required ancillary accommodation, is given at Appendix - V.

Effect of Recommendations:

13. It has already been indicated in Section II para 15 that our recommendations relating to the space requirements would bring about a saving of 10% in the carpet area. Apart from the cost of land which would be saved on this account, there would be saving in the cost of construction also. The total built-up area for a School with five class rooms and other ancillary accommodation (without Verandah) on the basis of corporation's existing specification etc. for permanent/semipermanent and tubular structures comes to 2890 and 2585 sft. respectively. The estimated cost of such schools would come to Rs 34,680/-, Rs 28,900/- and Rs 22,618/- for permanent semipermanent and tubular structure respectively. The built up area, excluding lobby, according to the revised dimensions etc. suggested by us works out to 228.72 sq.m. (2390 sq.ft.) and its cost would be Rs 19622/-. Thus the saving on one school building will be Rs 15,058/- Rs 9,278/- and Rs 2,996/- as compared with the permanent, semi-permanent and tubular structures respectively.

IV - SUGGESTIONS FOR FURTHER ECONOMIES

Doors and Windows:

Doors and Windows cost nearly 15 to 20% of the total cost of a building while the frames constitute 25 to 30% of the complete cost of the doors and windows. Because of scarcity and high cost of seasoned first-class timber, second class wood (usually unseasoned) is used at present. This type of wood is not durable and is also fairly costly. Frames made of reinforced concrete could overcome the disadvantages due to use of unseasoned timber at lower initial and recurring costs than timber. This will easily give a saving of 25% as compared to timber. The C.B.R.I., Roorkee have made extensive experiments on the subject. Their recommendatiins are given in Appendix IV.

Walls:

2. Increasing cost of material has resulted in the adoption of .228 m. (9") or thinner external walls which cannot withstand the effect of rain. Cavity walls have been extensively adopted in the Western countries because of their superior performance as regards thermal insulation, sound insulation and resistance to rain penetration. This type of construction is, however, rarely adopted in India even in highly humid or snow-bound areas. The chief reasons appear to be inadequate experience in this type of construction, its relatively higher cost and the satisfactory behaviour of thick solid walls. Use of 8" cavity walls in lieu of 9" solid walls would result in a saving of 30% in bricks and mortar. Such walls will also give better protection against rain penetration and heat. The C.B.R.I., Roorkee have carried out trials on .20 m. (8") cavity walls (2 leaves of 7.62 cm. (3") with a 5.08 cm. (2") cavity in between) and subjected them to a series of tests. Their findings are given in Appendix IV.

3. Besides adoption of this type of walls has certain indirect advantages e.g.:-

i) Lesser thickness of the walls results in saving in space, permitting better utilisation of the permissible plinth area.

ii) Because of the high resistance to rain penetration, internal finish is likely to be more lasting.

iii) Plastering may not be necessary except in areas of severe exposure.

Lintels:

4. Thin R.C.C. lintels 7.62 cm. (3") may be used. R.C.C. lintels reinforced with 3 bars of .95 cm. (3/8") diameter would be readily used on opening upto 1.83 m. (6') wide. Tests on such lintels were carried out at the C.B.R.I. Roorkee (vide Appendix - IV).

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Appendix - I
(Ref: Para 12 Page 7)

I.S.I. STANDARDS FOR SANITARY FACILITIES

FITMENTS	NURSERY SCHOOLS	SCHOOLS OTHER THAN NURSERY SCHOOLS		BOARDING SCHOOLS	
		For Boys	For Girls	For Boys	For Girls
Water closets	1 per 15 pupils or part thereof	1 per 40 pupils or part thereof	1 per 25 pupils or part thereof	1 for every 10 pupils or part thereof	1 for every 8 pupils of part thereof
Ablution taps	1 in each water closet	1 in each water closet	1 in each water closet	1 in each water closet	1 in each water closet
	1 water tap with draining arrangements shall be provided for every 50 pupils or part thereof in the vicinity of water closets and urinals				
Urinals		1 per 20 pupils or part with thereof		1 for every 25 pupils or part thereof	
Wash besins	1 per 15 pupils or part thereof	1 per 40 pupils or part thereof	1 per 40 pupils or part thereof	1 for every 10 pupils or part thereof	1 for every 10 pupils or part thereof
Baths	1 bath-sink per 40 pupils			1 for every 10 pupils or part thereof	1 for every pupils or part thereof
Drinking water fountains	1 for every 50 pupils or part thereof	1 for every 50 pupils or part thereof	1 for every 50 pupils or part thereof	1 for every 50 pupils or part thereof	1 for every 50 pupils or part thereof
Cleaner's sinks		1 per floor, min. →		← 1 per floor, min. →	

For teaching staff, the schedule of fitments to be provided shall be the same as in the case of office buildings (See Table II).

Appendix - II
(Ref: Page 10 Para 1)

TYPES OF STRUCTURES CONSTRUCTED BY THE MUNICIPAL CORPORATION OF DELHI

Specifications	Classification of Buildings			
	Permanent	Semi-Permanent	Sloping (Pent) Roofed structures	
			Tubular	Improvised
Walls	Brick in cement Mortar.	Brick in cement Mortar.	Brick/mud Mortar	Brick in mud (5' high side walls)
Roof	R.C.C.	R.C.C.	Asbestos sheets on Tubular columns & Trusses	Asbestos sheets on Angle Iron Trusses and purlins and Pipe columns
Floor	Cement Concrete	Cement Concrete	Cement Concrete	Brick on edge
Verandah roof	R.C.C.	Asbestos sheets	-	-
Doors & Windows	Teak Wood	Kail or Deodar	Kail wood	-
Cost per sft.	Rs 12.00 np.	Rs 10.00 np.	Rs 8.75 np.	Rs 5.62 np.
Average size of Class Room (Sq.ft.)	18'x22'=396 sft.	18'x22'=396 sft.	20'x19$\frac{1}{4}$'=385 sft.	18$\frac{1}{4}$'x16$\frac{1}{4}$'=300 sft.

Appendix - III
(Ref: Page 12 Para 8)

ESTIMATED COST OF A CLASS ROOM WITH DOUBLY CURVED TILE ROOFING

		Rs.
1.	Earth work in excavation in foundation trenches etc. in all kinds of soil (excluding loose filled up soil, soil containing 50% or more of kankar mooram or/and shingle saturated soil and rock) lift upto 5' stacking the excavated soil not more than 10' clear from the edge of the excavation and then returning the stacked soil in 6" layers when required into plinth sides of foundations etc. consolidating each layer by ramming watering and then disposing of all surplus excavated soil as directed with in a lead of one chain. 496 cft. @ Rs 33/- % cft.	16.00
2.	Providing and laying cement concrete 1:5:10 one cement 5 J.sand and 10 D.Q. stone ballast 2" and down guage 125 cft. @ Rs 91% cft.	114.00
3.	2nd class brick work in cement 1:8 one part cement 8 J. sand in foundation plinth 226 cft. @ Rs 85% cft.	192.00
4.	½" cement plaster 1:4 (1 cement, 4 J. sand) 59 sft. @ Rs 14.50% sft.	9.00
5.	Applying a coat of hot bitumen (mixphalt 80/100 or equivalent) using 35 lbs. per % sft. on damp proof course after cleaning the surface with a piece of cloth lightly soaked with kerosene oil 59 sft. @ Rs 9.50% sft.	6.00
6.	2nd class brick work in cement 1:8 (1 cement, 8 J. sand) in super 643 cft. @ Rs 93% cft.	598.00
7.	R.C.C. work 1:2:4 (1 cement, 2 B.P. sand, 4 D.Q. stone ballast ¾" down gauge) in lintels beams and columns with or without caps and bases (round Col. excluded) including rendering or plastering the exposed surface with cement mortar 1:3 (1 cement, 3 J.sand) of sufficient thickness to give a smooth finish including centring and shuttering but excluding cost of reinforcement. 34.70 cft. @ Rs 2.10 cft.	89.00

		Rs.
8.	R.C.C.work 1:2:4 (1 cement, 2 B.P. sand, 4 D.Q. stone ballast $\frac{1}{2}$" down gauge) in chajjas including rendering or plastering the exposed surface with cement mortar 1:3 (1 cement, 3 J. sand) of sufficient thickness to give a smooth finish including centring, shuttering but excluding cost of reinforcement 11.12 cft. @ Rs 3.87 cft.	43.00
9.	Providing and laying lime concrete with $1\frac{1}{2}$" and down gauge Delhi Q. stone ballast and mortar 1 lime, 3 J. sand 88 cft. @ 71% cft.	62.00
10.	Filling in Plinth with J. sand under floors including watering, ramming consolidating and dressing complete 88 cft. @ Rs 17% cft.	15.00
11.	$1\frac{1}{2}$" cement concrete flooring 1:2:4 (1 cement 2 B.P. sand, 4 D.Q.S.B. $\frac{3}{4}$" and down gauge) finished with a floating coat of neat cement 359 sft. @ Rs 36.50% sft.	131.00
12.	Half brick masonry (2nd class) in cement 1:3 (1 cement: 3 J. sand) in superstructure 25 sft. @ Rs. 48/-% sft.	12.00
13.	1st class kail wood wrought, framed and fixed in doors window clerestory window frames other frames and trusses 5.9 cft. @ Rs 13.50 cft.	80.00
14.	Providing and fixing $1\frac{1}{2}$" 1st class kail wood panelled, glazed, or panelled and glazed shutters for doors windows and clerestory windows including iron fittings complete 53.8 sft. @ Rs 2.56 sft.	138.00
15.	Providing 15"x$1\frac{1}{2}$"x$\frac{1}{2}$" flat iron hold fasts including fixing to frame with $1\frac{1}{2}$" screws and embedding in cement mortar 1:4 (1 cement : 4 J.sand) 22 Nos. @ Rs 0.81 each.	18.00
16.	Cement plaster 1:6 (1 cement, 6 J.sand) $\frac{1}{2}$" thick 1108 sft. @ Rs 12.50% sft.	139.00
17.	Cement plaster 1:6 (1 cement, 6 J. sand) 5/8" thick on rough side of 9" wall 725 sft. @ Rs 14.50% sft.	105.00
18.	Making black boards 8'x4' wide moulding of specific specification 1 No. @ Rs 14/- each	14.00
19.	Tuck or weather struck pointing on bricks with cement mortar 1:2 (1 cement, 2 J.sand) 11 sft. @ Rs 12.50% sft.	1.00

20.	White washing with lime on new work (three or more coats) to give an even shade. 1238 sft. @ Rs 1.6% sft.	13.00
21.	Colour washing such as green blue or buff on new work (two or more coats) including a base coat of white washing with lime to give an even shade. 1190 sft. @ Rs 1.19% sft.	14.00
22.	Providing and fixing precast reinforced cement concrete slabs 1:2:4 (1 cement, 2 B.P. sand 4 D.Q. stone ballast ½" guage and down) 1" to 3" thick in shelves etc. including rendering or plastering exposed surfaces with cement mortar 1:3 (1 cement, 3 J. sand) of sufficient thickness to give a smooth finish and a floating coat of neat cement but excluding the cost of reinforcement 1.3 cft. @ Rs 3.56%cft.	5.00
23.	Painting priming coat of wood work consisting of a mixture of 7 lb. of red lead 7 lbs. of white lead and 1 gallon of D.B. linseed oil. 136 sft. @ Rs 4.87% sft.	7.00
24.	Painting 2 coats (excluding priming coat) with chocolate red grey or buff paint of approved quality on new steel or wood work. 136 sft. @ Rs 6.50% sft.	9.00
25.	Mud phuska 2" thick or of puddled clay with bhusa at 1 seer/4 cft. of clay on roof laid to slopes consolidated and plastered with ½" thick mud gobri mortar 3:1 (3 mud: 1 cowdung) and covered with tiles bricks grouted with cement mortar 1:3 (1 cement: 3 J. sand) and finished neat 352 sft. @ Rs 40.50% sft.	143.00
26.	Painting top of roof with hot bitumen (mex-phall 80/100 or equivalent) at 35 lbs./% sft. impregnated with a coat of Bedurpur sand at 2 cft./% sft. cleaning the surface with brushes and applying K.oil complete 352 sft. @ Rs 10.75% sft.	38.00
27.	Making khura 1½'x1½' with 2" thick cement concrete 1:3:6 (one cement 3 B.P. sand 6 D.Q. stone ballast ¾" down gauge) furnished with ¼" cement plaster 1:4 (1 cement 4 B.P. sand) and a coat of neat cement rounding the edges and making finishing out-let complete 1 No. @ Rs 1.87 each.	

28.	Making Bottom thare as per specification 6 sft. @ Rs 0.87 sft	
29.	Providing and fixing asbestos cement offset for rain water pipe with M.S. holder bat clamp fixed with wall face with cement mortar 1:4 (1 cement 4 J. sand) 6" projection 4" dia 1 No. @ Rs.4/81 each.	5.00
30.	Providing and laying doubly curved tiles of cement concrete 1:2:4, 1 cement 2 B.P. sand 4 D.Q. stone ballast ½ down gauge including cost of moulds neat finishing and pointing the joints from below with cement mortar 1:2 (1 cement 2 J. sand) including hoisting etc. complete as per instructions. 70 No.@ 1/10 each	77.00
31.	R.C.C. work in precast secondary beams 1:2:4 (1 cement: 2 B.P. sand : 4 D.Q. stone ballast ½" down gauge) including plastering or rendering exposed surface with cement mortar 1:4 (1 cement 4 J. sand) of sufficient thickness to give smooth surface excluding cost of reinforcement but including cost of hoisting in situ and balli supporters till the roof is completed as per direction 16.8 cft. @ Rs 5.30%cft.	89.00
32.	Cement concrete 1:2:4 (1 cement: 2 B.P. sand 4 D.Q. stone ballast ½" down gauge) to fill hanches golla and lead plates etc. 65 cft. @ Rs 195/- % cft.	127.00
33.	Mild steel reinforcement for R.C.C. and R.B. work including bending binding and placing in position. (Complete) 700 lbs. @ Rs 0.37/lbs.	263.00
34.	Providing and fixing M.S. round or square bars at required spacing in wooden frames of windows and clerestory windows. 125 lbs. @ Rs 0.37 lbs.	46.00
	Total	2625.00
	Add 3% contingencies:	79.00
	Total	2704.00

Area of room = 23½'x17½' = 411.25 sft.	
Cost per sft. =	Rs 6.57
Add 25% on account of increase in market rates since 1955	Rs 1.64
Cost per sft.	Rs 8.21

Analysis of rate for manufacturing doubly curved tiles including hoisting in position and pointing from below

100 tiles of 2'-2"x2'-2"x¾"

1. Concrete 1:2:4 $100 \times 2\frac{1}{6} \times 2\frac{1}{6} \times \frac{1}{16} = 27.6$	
Add 5% wastage = 1.38	
28.98	
29 cft. @ Rs 195% cft.	Rs 56.55
2. Add for moulds polythene cloth etc. L.S.	1.00
3. Hoisting of 100 tile based on hoisting of 35 tiles	
1 mason @ Rs 5/- = 5.00	
4 mazdoor @ Rs 2/- = 8.00	
Add for centring plus shuttering & hire charges = 3.00	
16.00	
say -/7/- per tile	43.75
4. Pointing below L.S.	5.00
Total	106.30
Add 10% contractors profit: on Rs 49.75 nP.	4.98
Total	111.28

Cost per tile Rs 1.11 say Rs 1.10

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Analysis of rate for Sec. beam 5" x 3½" x 11½' precasted rendered and hoistea in situ.

unit/cft.

contents: 11½x5/12x7/24 = 1.4 cft.	
concrete 1:2:4 @ Rs 195/- % of cft.	2.73
frame work 3 planks 12' long & clamps etc.	0.37
cement plaster 1/4 with neat finish 2x11½x7/24 = 7 sq.ft. 1x11½x5/12 = 5 sft. 12 sft. @ Rs 15.50% sft.	1.86
Hoisting charges 1 mason and 4 beldars for one day fixed 6 secondary beams 1 Mason plus 4 Beldars plus sundries Rs 5/- plus Rs 8/- plus Re 1/- = Rs 14/- Cost per sec beam 14/6	2.33
Total	7.29
Add 10% contractor's profit on hoisting charges:	0.23
Total	7.52

Cost/cft = $\frac{7.52}{1.4}$ Rs 5.30

Appendix - IV
(Ref: Page 15 Para 1)

C. B. R. I. RECOMMENDATIONS

(a) R.C.C. Frames For Doors & Windows :-

Doors and windows cost nearly 15 to 25 per cent of the total cost of a building, while the frames constitute 25 to 30 per cent of the complete cost of the door or window. Because of the scarcity and high cost of seasoned first class timber, second class wood - usually unseasoned - is used at present. This type of wood is not durable and is also fairly costly. Frames made of reinforced concrete could overcome the disadvantages due to use of unseasoned timber at lower initial and recurring costs than timber. But the previous experiences with R.C.C. frames have not been satisfactory mainly because of the difficulty of devising suitable arrangements for hanging the shutters and unsatisfactory finish. Investigations have been carried out in the Central Building Research Institute to arrive at the most economical design of R.C.C. frames and to evolve simple fixtures for hanging the shutter. As a result of performance tests, it has been found that the frames could be of a section 3½". x 2½" reinforced with 3 Nos. 1/4 in. dia. bars, for openings upto 7' x 7'. This compares favourably with the existing designs which utilises sections upto 4" x 3" reinforced with 6 Nos. of 10 SWG wire.

Good finish can be obtained by using steel, or sheet lined wooden moulds and by vibrating the concrete. Decorative treatments such as terrazzo finish or painting can be had where a superior finish is required.

The frames as evolved at the Institute are cheaper to the extent of about 50% as compared to those made out of first class hard wood and about 40% as compared to those made out of second class hard wood.

Size and Reinforcement -

The minimum section of 3½". x 2½" reinforced with 3 bars 1/4" dia. is recommended for adoption for all openings upto 7'x 7' which will cover most of the requirements.

Mould -

The mould for casting the R.C.C. frames may be of timber or steel. When timber is used, it is advisable to line it with M.S. or G.I. sheet for longer life and better finish of the product. Lining also helps in reducing undue distortion of the frame due to warping and shrinkage.

Casting -

1:2:4 concrete mix (with 3/8" mx. size of aggregates) is recommended. One 1/4" dia. bar should be left projecting out by about 2" from the top ends of vertical members and 1/2" dia. holes left in the top horizontal members to fit in with the vertical members. The fixtures for hinges and hold-fasts should be inserted in the mould at the proper positions; the reinforcement cage should be placed allowing for a cover of 3/8" and then the concrete poured in the mould. It is advisable to use a vibrating table or alternatively a small shutter vibrator may be used. Compaction by hand may provide the required strength but the finish is likely to suffer.

Removal Of Members -

The members should be removed from the mould after about 24 to 28 hours depending upon the climate. They should then be allowed to cure in a water tank for a fortnight. Finally they should be removed to a covered place and stored for a month before use.

Erection

The R.C.C. frames may be assembled at site and erected as in the case of timber frames. It, however requires some care in handling, as the frame is heavier than a timber frame and the joints are liable to give way, if not handled carefully. Alternatively the vertical members may be held in position and the top member placed over the vertical members. The whole frame is then plumbed and supported temporarlily, till the hold fasts are embedded in jambs. Cement sand slurry of mix 1:3 should be used in grouting the joints between the vertical and top members. In cases where four members are used e.g. in window frames or doors having sills, the sill members are bedded at the ends. It is advisable to leave a gap between the bedding mortar at ends to enable the sill to take its correct set under the load as the central portion carries less load than at the ends. This gap can be filled in later after the wall above the door has reached the roof level.

Finish -

A good finish can be obtained by using moulds having a smooth surface and by using vibrators. The defects, if any, can be made good by rubbing the frame with carborundum stone before erection.

In superior class of buildings where decorative treatments are desired the frames can be had with terrazzo finish cast on them or where required, painted with any suitable tint of oil paint after erection. When terrazzo finish is given, the R.C.C. frames should be made smaller to the extent of thickness of the finish viz. 1/4". The mix for terrazzo should be of 1 cement : 2 marble chips and the terrazzo coat laid on the three exposed faces of the members while casting the frame.

Paints used for treating the R.C.C. frame should normally be cement paints of an approved brand; when an oil paint finish is desired, it should be done in three stages:-

(a) Priming coat - 2 coats of Alkaly fast Primer should be applied.

(b) Under coat should conform to I.S. 520-1954.

(c) Finishing coat should consist of two coats of synthetic enamel paint conforming to I.S. 520-1954.

(b) Cavity Walls

Cavity walls have been extensively adopted in the western countries because of their superior performance as regards thermal insulation, sound insulation and resistance to rain penetration. This type of construction is however rarely adopted in India even in highly humid or snow bound areas. The chief reasons appear to be inadequate experience of this type of construction, its relatively higher cost and the satisfactory behaviour of thick solid walls. Increasing cost of materials has resulted in the adoption of 9" or thinner external walls which cannot withstand the effect of rain. Adoption of cavity walls would meet this objection, provided they could be made at the same or at a lower cost than 9" (one brick) thick walls.

As a result of trials, 8" cavity walls (two leaves of 3 inches with a 2" cavity in between) has been devised and subjected to a series of tests in accordance with A.S.T.M. standard No. E 72-55. As is usual, G.I. wire ties are provided at suitable intervals of (2'-6" horizontally, 1'-6" vertically staggered) with additional ties at pillars and jambs (with frogs exposed to the exterior). If cross walls or partitions are not available, the walls are transversely strengthened by means of brick-on-edge pillars projecting to the exterior, at 8'-10" intervals. The pillars are linked with the outer skin only, thereby providing a continuous cavity, where pillars are not desired (e.g. in party walls), the two skins may be connected by cross, bricks, although this tends to take away some of the benefits of the cavity.

The ultimate compressive strength of 8' x 4' free standking panels with frogs exposed have been observed to be about 48 tons or about 12 tons per Rft. as against a load of about 4.2 tons per Rft. likely to be met with in a two storey building. The lateral strength for free and loaded panels have been observed to be 950 lbs. and 2000 lbs. respectively which worn out to 30 and 62 lbs. per Sft. respectively, and amply meet the stipulations in the I.S.I. code for noncoastal and coastal regions (10 and 15 lbs. per Sft.). Impact load tests with a sand bag weighing 60 lbs. (as prescribed by A.S.T.M. standard) have indicated that cavity walls satisfy the requirements. This type of cavity walls can be readily adopted for load-bearing walls for buildings upto two storeys and as curtain walls in multistoreyed construction.

Adoption of this type of wall has also got certain indirect advantages as under :-

(a) Lesser thickness of the walls results in saving of space permitting better utilisation of the permissible plinth area. This advantage is to some extent offset by the projecting pillars. It could be overcome by providing internal brick bonding, esp. where the walls are not exposed to the atmosphere.

(b) It is necessary to plan and provide for all fittings and fixture, as the work proceeds, so as to reduce the chance of walls being broken up a number of times, as is commonly done in the case of 9" solid walls.

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(c) The frogs of the bricks may be made to face the exterior, thereby providing a very attractive appearance. Exposed frogs can also serve as an excellent key for the plaster, although some extra consumption of mortar is involved. Plastering is not necessary, except in areas of severe exposure.

(d) Because of the high resistance to rain penetration, internal finish are likely to be more lasting.

(e) The thickness of the skins makes the mason more careful about line and plumb and resort to double scaffolding is readily acquieseed to by the contractor.

Besides having better thermal and sound insulation, this type of wall saves about 30% of bricks and mortar as compared to a 9" solid wall. Time studies on construction site (wherein this type of cavity walls was adopted for the whole building) indicate that an average mason job trained for about 7 days can build about 40 sft. of wall per day. Use of simple gadgets for preventing dropping of mortar can further increase the productivity. The cost of 100 FS of the 8" cavity wall built in c.m. (1:3) is about 10% less than that of a 9' solid brick wall in c.m. (1:6)

(c) R.C.C. Lintels In Brick Walling

The actual loads to be carried by a lintel are difficult to determine, since these greatly depend upon the extent of arching action developed within the masonry on top. Tests conducted in U.K. on plinth beams supported on piles have indicated that, subject to certain conditions, the plinth beams carrying brick walls may be designed on the basis of bending moments equal to WL/50 or WL/100 where W is the total load on the lintel (including that contributed by the roof) and L is the span. It has also been established that such beams largely act as tension members with the compression being taken up by the brick work. This is greatly in contrast with the conventional lintels designed to carry a triangular loading and all loads falling within this triangle. Since lintels over door or window openings are also subjected to conditions of loading comparable to the one referred to above, it was decided to design lintels on this principle (viz. WL/100) and perform the loading tests. Although the calculated designs gave a lower figure, the depth of the lintel was restricted to 3" to correspond to a course of brick work and give adequate rigidity against deflection during handling and hoisting. Tests on 3" thick lintels (having about 1'-6" brick masonry on top) reinforced with 3 bars of 3/8" diameter placed centrally without any cranking carried out showed that failure took place under a load of about 30 tons and that the deflections were well within the permissible limit of L/360 (L being the span). Since the total load on a 6'. lintel in a single storey building is usually of the order of 3 tons, lintels based on the above design have adequate structural strength in normal conditions of use. Because of lower weight, lintels based on this design principle can be readily precast and save considerable time on the site as compared to those cast in situ.

Further work is in progress to asses the problems associated with use of lintels thinner than 3". However 3" thick R.C.C. lintels reinforced with 3 bars of 3/8" dia. can be safely recommended for openings upto 6' clear span (having brick masonry to a minimum height of 1'-6" above the lintel) for normal buildings. The reinforcement should be placed in the centre the precast lintels supported (by means of a central prop) till the wall gains the necessary strength. Adoption of this type of lintels saves approximately 50% of the cost and material, as compared to lintels based on conventional designs. Where required, provision of R.C.C. chajjas can be readily made by projecting the steel bars during the casting of lintels and chajjas cast in place subsequently. Where two lintels cross each other half rebated joints may be provided while precasting the lintels.

(d) Doubly curved tiles

The cost of a R.C.C. roof usually amounts to 25-30% of the total building cost. In terms of money, its cost ranges between Rs 2.50 to Rs 4.00 per sft. (depending on the span and loads to be carried) out of which 75-80% forms the cost of the slab and 20-25% forms the cost of form work. Efforts were therefore made to evolve economical flat roofs, which while reducing **the** consumption of materials, overcome and doing away with the need of extensive shuttering, overcomes the above disadvantages.

It is well known that R.C.C. slabs as per conventional designs have a very large factor of safety. The thickness of slabs cannot however be substantially reduced without incurring the risk of excessive deflections corrosion of reinforcement, thermal or shrinkage cracks and lower thermal efficiency. Efforts were therefore made to evolve economical flat roofs. One of the roofs evolved employs small doubly curved tiles 2'-3" x 2'-3" x 3/4" thick of plain cement concrete (1:2:4 with aggregate of 3/8" size). These tiles can be cast with the help of a timber form work of the required size, with a piece of hessian cloth tacked on to it. These tiles are placed on partially precast R.C.C. beams (supported during construction) with a compression flange of in-situ concrete. An average of 4" thick lime concrete is provided over the surface to provide a protective layer and distribute the loads. The individual unit withstands a static load of about 210 lbs./sft. while the assembled roof withstands a static load of about 280 lbs./sft. Against impact loads, the individual tiles are not very strong (tiles break when a bag weighing 60 lbs. is dropped from a height of 1' 6") but the roof assembly with the haunches between the tiles filled in with concrete (which provides the restraint) withstands an impact of a 60 lbs. sand bag dropped from a height of 10'. 6") but the roof assembly with the haunches between the tiles filled in with concrete (which provides the restraint) withstands an impact of a 60 lbs. sand bag dropped from a height of 10 feet. This type of roof saves about 24% in consumption of cement and 46% in consumption of steel as compared to 4" thick R.C.C.

slab construction. It provides the advantage inherent in precasting such as lesser erection time, dispensing with extensive shuttering, lesser liability of shrinkage cracks, without entailing use of mechanical lifting arrangements.

Although no standard for impact load exists, the U.K. research station recommends an impact loading of 56 lbs. (sand contained in a standard bag) dropped from a height of 4'. This type of roof is therefore adequately strong to withstand the loads met with in normal buildings. It is however, not suitable where the roofs are liable to be subjected to heavy concentrated loads, not catered for in the designs. It is therefore recommended for roofs not subject to constant usage and for spans upto 16' beyond which manual handling of precast beams would present difficulty and relative savings are appreciably reduced. During construction, care is necessary to ensure that the tiles are not subjected to unduly heavy construction loads (esp. impact till the haunches are filled in and protective lime concrete is provided.

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